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To: U. S. Department of Transportation Dockets
Docket No. FAA-1999-5833 -6
400 Seventh St. SW, Room Plaza 401
Washington, DC 20590

ORIGINAL

From: ACTA Inc.
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Subject: Review of Licensing and Safety Requirements for Operation of a Launch Site

The attachment contains comments by the staff of ACTA Inc. regarding the NPRM for *Licensing and Safety Requirements for Operations of Launch Sites.* Questions regarding our response can be directed either to Jon D. Collins, President, ACTA Inc. (3 10) 530-1008 (**collins@actainc.com**) or to Harold Reck, Manager of Advanced Projects, ACTA Inc. (805) **733-5054 (reck@actainc.com)**.

We are grateful for the opportunity to be able to participate in the review/comment process. We are appreciative of the important role that the FAA must play in the protection of the public and in the future of Commercial Space in the United States. If we can be of any additional service, we will be glad to help.

ACTA also submitted two other direct responses to the FAA:

1. A response to the Advisory Circular on Expected Casualty Calculations. This was submitted by mail to FAA/AST, Mr. Ronald Gress, on 20 July 1999.
2. A response to the NPRM for Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing RLV's. This was submitted by email on 20 July 1999.

ACTA also prepared a response to the draft NPRM, *Licensing and Safety Requirements for Launch from a Non-Federal Launch Site* as an input to the response by the Eastern and Western Ranges in February 1999 and participated in FAA/AF Working Group meetings on this topic.

for Harold C. Reck
Jon D. Collins
President

22 September 1999

Attachment 1

ACTA Inc. Comments on Licensing and Safety Requirements for Operation of a Launch Site, Docket No. FAA-19994833, Notice No. 99-07

1. SUMMARY

1.1 It appears that the risk analysis procedure for downrange risks was released before the consequences of the methods were evaluated. An application of the methods to launches from CCAS involving downrange overflight of land masses indicate that medium to large vehicles cannot be launched without significantly exceeding the acceptable risk criteria specified in the document. Very simply, if these methods were applied to most CCAS launch scenarios, they would be found unacceptable.

1.2 The FAA embraces Q-D criteria and assumes that it protects the general public from the "effects" of accidental explosion – it does not. The Inhabited Building Distance (IBD) specified by the DoD 6055.9 protects at the level of 1 psi incident which still permits substantial glass damage and resulting casualties. It appears that the approach used for explosive siting is much less conservative than the approach used for launch risks.

1.3 The FAA's selection of 30×10^{-6} is based on the successful use of that criterion by the ER and WR and published in EWR 127-1. However, EWR 127-l has relief if the criteria are exceeded, i.e. the Commander has the authority to proceed with the launch, based on circumstances, with risks up to 300×10^{-6}. With the FAA's apparent decision not to permit any risk above 30×10^{-6}, coupled with a very conservative approach to risk analysis, as demonstrated in the subject document, this could prove to be very detrimental to the U. S. Space Industry.

1.4 The document offers no insight into the source of numbers, such as casualty areas, that the FAA directs the license applicant to use. Suggest that references be identified.

1.5 Collective risk is defined as "the sum total related risk," yet the document does not address launch-related risk from potential toxic releases or far-field window breakage.

Also, debris risks to ships and aircraft cannot be completely ignored. These risks can be real. Are they additive to the debris risk?

1.6 The risk analysis methodology presented in the document is very simplistic. There are better methods available, albeit they may be more complex. The NPRM does not allow for any other methodology.

1.7 The level of analysis in this document seems to assume that that the applicant will be very naïve and not have access to good tools or consultant support. For example, generally only vacuum impact prediction is presented. In reality, drag plays a large role and the impact points of debris with varying ballistic coefficients resulting from a single breakup time can stretch for hundreds of miles in the downrange direction. The methods shown do not demonstrate for the applicant an understanding of what is really happening.

1.8 The downrange risk method can only apply when there is some forward motion of the IIP. Consequently it can not be applied in a back azimuth direction – there is no methodology for risk analysis in the back azimuth direction other than the exclusion zone. It implies that there is no back azimuth risk because everyone is outside the exclusion zone .

2. SPECIFIC COMMENTS

2.1 The IIP rates are unrealistically low, particularly late in flight. When a vehicle is in a coast phase, the IIP does not move. The periods of powered flight are the only periods where the IIP has significant movement. If only these periods are considered, the average IIP rate will increase. Using a lower IIP rate, as is the case in this document, inflates the computed risk.

2.2 The suggested casualty areas seem very high. Where did they come from? There is no reference or justification. According to the document (Table C-3), which appears to give the areas in statute miles squared, they can be more than 54 million square feet for a large vehicle during the first 49 nm of IIP range, equivalent to 1126 football fields (between the goal lines). They are even high for thedownrange area during the final stage (20 million square feet – 416 football fields) and an explosion upon impact is unlikely during the final stage of flight. These casualty area numbers are a prime contributor to the unrealistically high risks computed by these methods.

2.3 Regarding the assumption of the public being safe with Q-D, Q-D does not ensure "that the effects of an explosion do not reach the public." The Q-D criterion for public buildings (houses, schools , churches, etc.) allows "a glass fragment serious injury probability of up to 30%." (Quote from "Evaluation of Explosive Safety Storage Criteria," by Custard, Donahue and Thayer, Falcon Research and Development, Denver Colo., AD871 194, May 1970). Recent work performed for the DoD Explosive Safety Board (RBESCT) confirms that there is a considerable risk from flying glass in public structures that are sited in conformance with Q-D regulations and this risk increases as the impulse in the shock wave increases. More information on this will be made available to the FAA if so requested.

2.4 Page 34329 and 34362. The NPRM states that the over-flight exclusion zone is to be designed to protect an individual in the public at a level of risk of 30×10^{-6} casualties. This seems to be a rather loose criterion, although it is acknowledged that the collective risk limit is still 30×10^{-6}. The Range Commander's Council Standard suggests 1×10^{-7} <u>fatalities</u> for the maximum risk to the general public. The ER and WR have used 1×10^{-6} casualties as an individual risk limit for the general public. These numbers are published in the 30 SW Flight Safety Analysis Handbook.

If 30×10^{-6} was used as the basis for developing the distance, D_{max} in the NPRM, then D_{max} appears quite conservative for that risk level. As a basis of comparison, look at the constant risk isopleths in the paper, "Risk Based Siting of Rocket launch Facilities," by Collins and Baeker to be presented at Parari '99 in Canberra in November 1999. In that paper, Atlas IIAS is used as an example for risk based siting at CCAS. Atlas IIAS corresponds to an NPRM vehicle in the medium-heavy class. The NPRM specifies that D_{max} is 10600 ft (3.23 km) for a medium-heavy vehicle. Looking at Figure 4 of the paper (reproduced below), the minimum distance of 10,600 ft (3.23 km) to the launch site boundary specified in the NPRM for a medium-large vehicle corresponds most closely with the near point of the 1×10^{-7} individual casualty risk isopleth for an Atlas IIAS with a 25% launch failure probability (a failure rate like a new vehicle). This indicates that the NPRM is either extremely conservative if using a 30×10^{-6} criterion, or that the D_{max} has nothing to do with 30×10^{-6}. In fact, the 10,600 ft (3.23 km) looks more like it fits the 1×10^{-7} isopleth for a vehicle having a 25% failure rate.

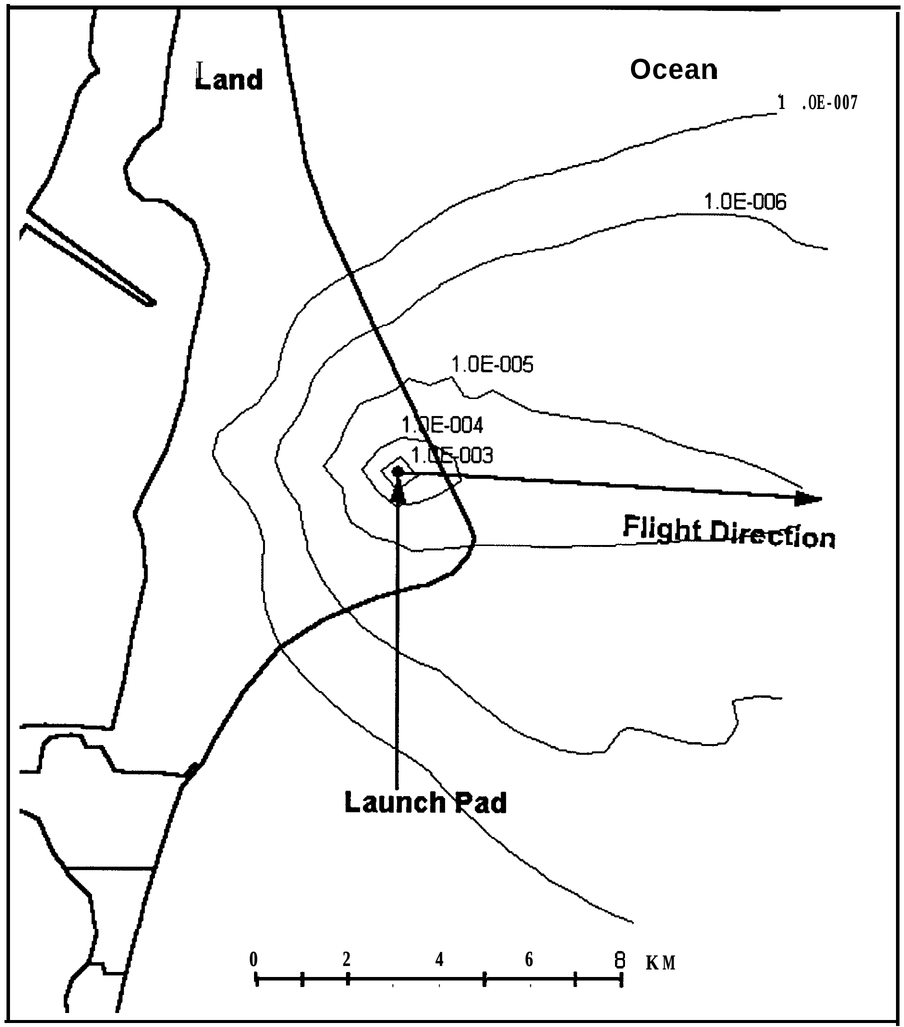

Figure 4. Contours of probability of casualty assuming a mission launch reliability of 0.75 (i.e. failure probability of 0.25)'

2.5 Page 34347. The document uses 58 ft-lb for 50% probability of fatality. We suggest that the FAA use a casualty criterion. There is more recent work in this area as discussed below.

Historically, the national ranges have used impact kinetic energy (KE) as a criterion for determining whether an inert fragment is capable of producing a casualty. This approach was challenged by the Range Commander's Council Risk and Lethality Commonality Team (RALCT). However, the RALCT lacked the resources to address the issue they

[1] From Collins and Baeker, "Risk Based Siting of Rocket Launch Facilities" Parari '99, Canberra, Australia, Nov. 1999.

identified. ACTA has been performing biomechanical simulations to investigate these criteria in support of the Eastern and Western Ranges. Analyses are still in progress. Nevertheless, there are several important conclusions from this work:

- Impact kinetic energy, by itself, is an inadequate predictor of whether or not an inert impacting fragment will produce a casualty. For a specified person, the fragment weight and kinetic energy together do provide a good indication of the potential for injury. A fragment striking a person causes the body of the impacted individual to move in response to the impact. The dynamics of the response motion is related to the level of injury that will occur.
- Thus, the impact kinetic required to produce a level of injury depends on the weight of the impacted individual.
- Frail and infirm individuals are more vulnerable than normal individuals who are, in turn, more vulnerable than robust athletic individuals.

A model is being developed that considers all of the above observations. The modeling effort is still in progress. Nevertheless, casualty probability distributions have been developed for the adult working population. The following table lists the median impact kinetic energy required to produce a casualty as a function of the fragment weight. It is recommended that these values be used as an interim basis for identifying hazardous fragments and that these values be updated as the analysis is finalized.

Weight(lb)	50% KE
1	20
5	35
10	70
40	120
100	240

2.6 Page 34393, Table E. DoD 6055.9 states that the IBD for quantities of Class 1.1 solid propellant ranging from 1 to 35,000 lb is 1250 ft. In the extreme, this says that 1 lb of 1.1 requires 1250 ft., while in Table E, up to 1,000,000 lb of 1.3 requires only 800 ft., even when quantities of 1.1 are present.

2.7 General comments on the development of launch corridors. Method A specifies a launch corridor method without revealing the methodology. It is assumed that the Method A “nominal trajectory” trace is to be a great circle arc; however, this is not stated. Method

B directs the applicant to use a method that relies entirely on a max-max lateral dispersion of a fragment with a ballistic coefficient of 3 psf up to a vehicle failure altitude of 50,000 feet, and then a kind of maximum lateral turn analysis for determining cross range dispersion after that. Impulsive velocities imparted to fragments from explosions are ignored throughout. Five sigma is assigned to the limits of the resulting boundary. No justification is given for the use of five sigma and, for that matter, there does not appear to be any real probabilistic basis for any of the dispersion analysis. In the risk analysis method the crossrange standard deviations are used to compute E_C. Presumably the "more accurate" Method B will improve the E_C calculation. In the past, using downrange risk models such as these, one could choose to vary the crossrange sigma up and down and compute the E_C as a function of sigma. Then a maximum E_C can be obtained within reasonable limits of the possible range of the crossrange sigma. This helps to eliminate some of the controversy about the determination of the width of the corridor.

2.8 The equation for casualty expectancy in Appendix C to Part 420 (page 34388) contains the ratio of the casualty area to the populated area (A, / A_k). This ratio should be limited to one (1 .O) to avoid the possibility of predicting more casualties, given impact, than the number of people in the population center.

The following are additional comments from the ACTA staff.

3. GENERAL COMMENTS

3.1 The lack of paragraph numbers in the various parts of the *Supplemental Information* section makes it difficult to provide comments. Suggest future Supplemental Information sections of NPRMs use an improved and more detailed paragraph identification or numbering scheme.

3.2 The analytical processes dictated by Appendixes A through D are limited and too restrictive. Other professionally competent methods have been developed to accomplish the same object that should be allowed by FAA/AST. For example, the Launch Area Risk Analysis (LARA) program that has been developed for the 30th Space Wing is routinely used at the WR for all launches and at the AFFTC for X-33.

3.3 Two other NPRM initiatives, <u>Licensing and Safety Requirements for Launch from a Non-Federal Launch Site</u> and <u>Licenses for RLVs And Reentry Operations</u>, and a draft

Advisory Circular, *Expected Casualty Calculations for Commercial Space Launch and Reentry Missions*, AC 43 1.35- 1, dated 4/1 2/99 also contains varying descriptions of specific analytical processes, in this case processes for performing risk analyses and computing E,. Suggest as a minimum, these methodologies be made consistent, not be limited to those derived from specific DAMP methods, and also provide for use of alternative methods accepted at other Federal spacelift ranges.

3.4 The NPRM provides excruciating details on how to handle explosive risks but does not consider public risks associated with either toxicity stemming from liquid or solid propellants and blast overpressure focusing. Experience indicates this can be a major factor in siting decisions and it is recommended that FAA provide guidance to applicants in these areas.

3.5 Although this NRPR has the potential to become a quality document, it is strongly recommended that it not be submitted for processing as a Final Rule in its present form. A Final Rule should wait until the numerous comments from reviewers are incorporated <u>and</u> another draft redistributed as an updated NPRM for another cycle of public (and industry) review. As discussed in the Supplementary Information section of the NPRM, the guidelines currently used to approve the four existing site operators licenses are adequate pending completion of a quality document, especially since the NPRM makes no statement regarding urgency or if any applications for site operator licenses are pending or anticipated.

4. ADDITIONAL SPECIFIC COMMENTS

4.1 Supplementary Information (SI), I. Background, C. Current Practices, pg. 34318, column 3, first ¶: The document indicates “the proposed rule would require an applicant to use specified methods to ---” – suggest that the applicant to allowed to use equivalent approved analysis methods and processes that have been validated by use at other Federal Ranges involved in ELV/RLV activities in addition to the limited and restrictive set described in Appendices A, B, C and D. Further in the same ¶ the document indicates “an applicant would be provided a choice of methods (2) to develop flight corridors---”- again, the “choice of methods” is too restrictive and limited. Further, the last sentence of this ¶ indicates that “the FAA would review the analysis to ensure the applicant’s process was correct”.

4.2 SI, II Discussion of Proposed Regulations, A - *Licensing and Safety Requirements for Operation of a Launch Site*, pg. 343 19, column 3, last sentence of 1 st ¶: States “the FAA will revisit ground safety issues in its development of rules for launches from non-federal launch sites" – it seems this "revisit" is equally critical to this NPRM dealing with licensing a launch site since it requires the "explosive site plan." Also the contents of footnotes 2 and 3 are too important not to be included in the body of the discussion and in Part 420. Suggest the document be revised to place proper emphasis on the contents of footnotes 2 and 3, and explain the interaction between FAA/AST and OSHA, EPA and ATF during operation of a launch site.

4.3 SI, *C – Explosive Mishap Prevention Measures,* 1st ¶, pg. 34324, column 1: The last sentence indicates "requirements of a more operational nature will be covered in another rulemaking." Suggest the document should indicate which of the several existing NPRM's or identify the new NPRM will address this topic.

4.4 SI, C, 2nd ¶, last sentence, pg. 34324, column 1: The sentence states that the NPRM on "launches from non-federal launch sites will cover other procedural measures to guard --- from electricity." The version of the internal draft NPRM for launch operators that was provided to the Air Force did not address this issue. Suggest FAA/AST confirm which NPRM should and does cover this area.

4.5 SI, B & C, pgs. 34320-34325: These discussions make liberal reference to DOD and NASA Standards that seems inconsistent with the national and industry objective of moving from military/government to commercial standards and specifications. Since OSHA, EPA and ATF regulations have the responsibility for safety during production and assembly (and DOT for shipping) of hazardous materials, why shouldn't this rules apply to launch site operations as well?

4.6 SI C, Static Electricity, last ¶, last sentence, pg. 34325, column 1: The sentence states that "the control of static electricity --- is best covered by the FAA in a future rulemaking on launches." Again, the version of the internal draft NPRM for launch operators that was provided to the Air Force did not address this issue. Suggest FAA/AST confirm which NPRM covers this area.

4.7 SI, D – Launch Site Location Review, last 2 sentences of 1st ¶, pg. 34326, column 3: These deal with "risks associated with a series of impact dispersion areas around the impact point for spent stages for unguided vehicles." As is the case for guided vehicles, it is obvious that the FAA/AST should be concerned about any population centers within the three-sigma dispersions along the entire trajectory.

4.8 SI, D, pg. 34326, column 3: This section, and numerous others throughout the document, refer to the $E_c \leq 30x1\,0^{-6}$ criteria for "collective risk,' and only briefly mentions "individual risk,' even though this may become the constraint. Suggest FAA/AST also consider establishing criteria for "individual risk,' since this is occasionally a significant consideration needed to adequately provide protection for the public.

4.9 SI, Table 1, pg. 34327 and Table 1 to § 420.21, pg. 34362: Note that the two tables are identical but have different titles. Suggest the same title be used. This is admittedly a minor point but it is part of a larger issue associated with mislabeled and incorrect information dealing with tables throughout the document.

4.10 SI, Table 2, pg. 34327: Lockheed Martin renamed the LMLV to "Athena" several years ago. Also, suggest the table be expanded to include the two families of EELVs.

4.11 SI, D, pg. 34328, column 3, last sentence of 2nd ¶: Be aware that the risks posed by normally jettisoned Delta 2 GEMS are in fact a significant element of concern for launches from the WR, and protection of personnel on offshore oil platforms does require special considerations including trajectory reshaping, carrying the GEMS after burnout, and sheltering or evacuating the crews on the platforms. Suggest the statement be tempered. Also, ignoring the existence of established major air corridors or shipping lanes seems shortsighted. Even if scheduled debris is not disposed of in these areas, FAA/AST should be apprised of the existence of these routes during the Site Location Review since some risk will always be present during launch when traffic is present.

4.12 SI, Part III, Part Analysis, pg. 34331 and Subpart A, § 420.5, pg. 34360, Definitions:

- *Flight Corridor:* Note use of the phrase "contain the <u>maioritv</u> of <u>hazardous</u> debris" – suggest FAA/AST needs to discuss the intent – what is meant by hazardous and what about the other potential 49% of the debris. Clearly the definition needs further "wordsmithing."
- *Impact Range:* Suggest the phrase "sub-orbital." The definition also applies to any scheduled jettisoned debris.
- *IIP:* Suggest the qualifying statement in the definition dealing with "in the absence of atmospheric drag effects, that is, a vacuum" be deleted since IIPs can be calculated

based on vacuum, drag and/or oblateness corrections depending on the application. The IIP for long-range sub-orbital vehicles (ICBMs) frequently require drag and oblateness corrections. The definition should acknowledge that several forms of IIP calculations are possible.

- *Launch site accident:* Suggest the definition could be clarified by either deleting "ground" or changing the definition to read "ground or launch activity."

4.13 § 420.15 (b)(l)(i), pg. 34361, column 1: Discussion calls for "impact dispersion area" but, again, the definition for this phrase is applicable only to sub-orbital launch vehicles. Typically the impact points and dispersion areas for items of scheduled jettisoned debris, such as spent stages, are needed for orbital launches. Also, 420.15(b)(1)(iii): suggest use of mean winds and wind covariance for the month.

4.14 § 420.23, pg. 34362, column 3 : Does the statement that "FAA will evaluate the adequacy of a launch site location for unproven launch vehicles --- on a case-by-case basis" imply that the "Site Operators License, Guidelines for Applicants," 8 Aug 95, discussed in Section C of Supplementary Information, will be the basis for this review. If not, then what are the criteria?

4.15 SI, App A, pg. 34339, column 2 to 34341, column 2: This section on "Map Requirements and Plotting Methods" is an interesting tutorial but suggest it could be replaced by simply stating what FAA wants to receive from applicants. Map scale and projections are not "black magic" and can be performed using geographical information system software tools that are readily available.

4.16 SI, App A, last ¶ on page 34341, column 1: This indicates that "commercially available GIS products are acceptable to the FAA for use ----if they meet the map and plotting method requirements in paragraph (b) of appendix B." The discussion in appendix A has a multiple page (pg. 34339-34341) tutorial on this subject that should be reduced to simple statements of requirement.

4.17 SI, App A, <u>Overflight Exclusion Zone</u>, pg. 34342, columns 1 & 2, 1st and 2nd ¶: First of several references to DAMP. DAMP is only one of several risk analysis programs currently in use at Federal launch ranges. The status and future plans for operational certification of DAMP are associated with the RSA program and may be uncertain at this time. FAA/AST should allow for inputs from other programs that are used at the Federal space-lift ranges.

4.18 SI, App A, Overflight Exclusion Zone, last ¶, pg. 34342, bottom of page and 34343, column 1: If used, the application of what appears to be an overly conservative approach to riskanalysis would likely prevent scheduled X-33 launches from AFFTC.

4.19 SI, App A, Launch Area, 1 st ¶, pg. 34343, column 2: The decision to base the analysis on a Delta II has several shortcomings. The families of commercial launch vehicles based on Castor-l 20 SRMs, such as Athena and Taurus, should also be considered in this analysis since this class of vehicle is perhaps more representative of those likely to be launched from a non-Federal launch site.

4.20 SI, App A, Launch Area, 2nd & 3rd ¶, pg. 34343, column 3, Figure 1 on pg. 34344, and Fig 2 on pg. 34345: These paragraphs and figures should better communicate that the 10 and 100 mile corridors are based on IIP space, not present position.

4.21 SI, App B, Launch Area, 1st ¶, pg. 34347, column 1: Ignoring the IIP displacement caused by a vehicles malfunction turn rates until the vehicle reaches an altitude of 50K ft seems unwise based on the turning potential of most ELVs and especially those derived from vehicles using Castor 120 SRMs. Suggest FAA needs to reconsider this assumption.

4.22 There are many typo's in this document that are not detailed in this review. Some affect equations, however, such as Equation Cl where γ has been inadvertently substituted for y. This error is repeated in other equations shown later. For the sake of brevity, Equaton C 1 includes the normal integral represented by Simpson's rule. Recommend that it be replaced by the normal integral with a single footnote saying that it can be approximated using Simpson's rule. Note that Microsoft EXCEL has a function, NORMDIST(x,mean,standard_dev,cumulative) that computes the normal integral to an accuracy at least as good as Simpson's rule.